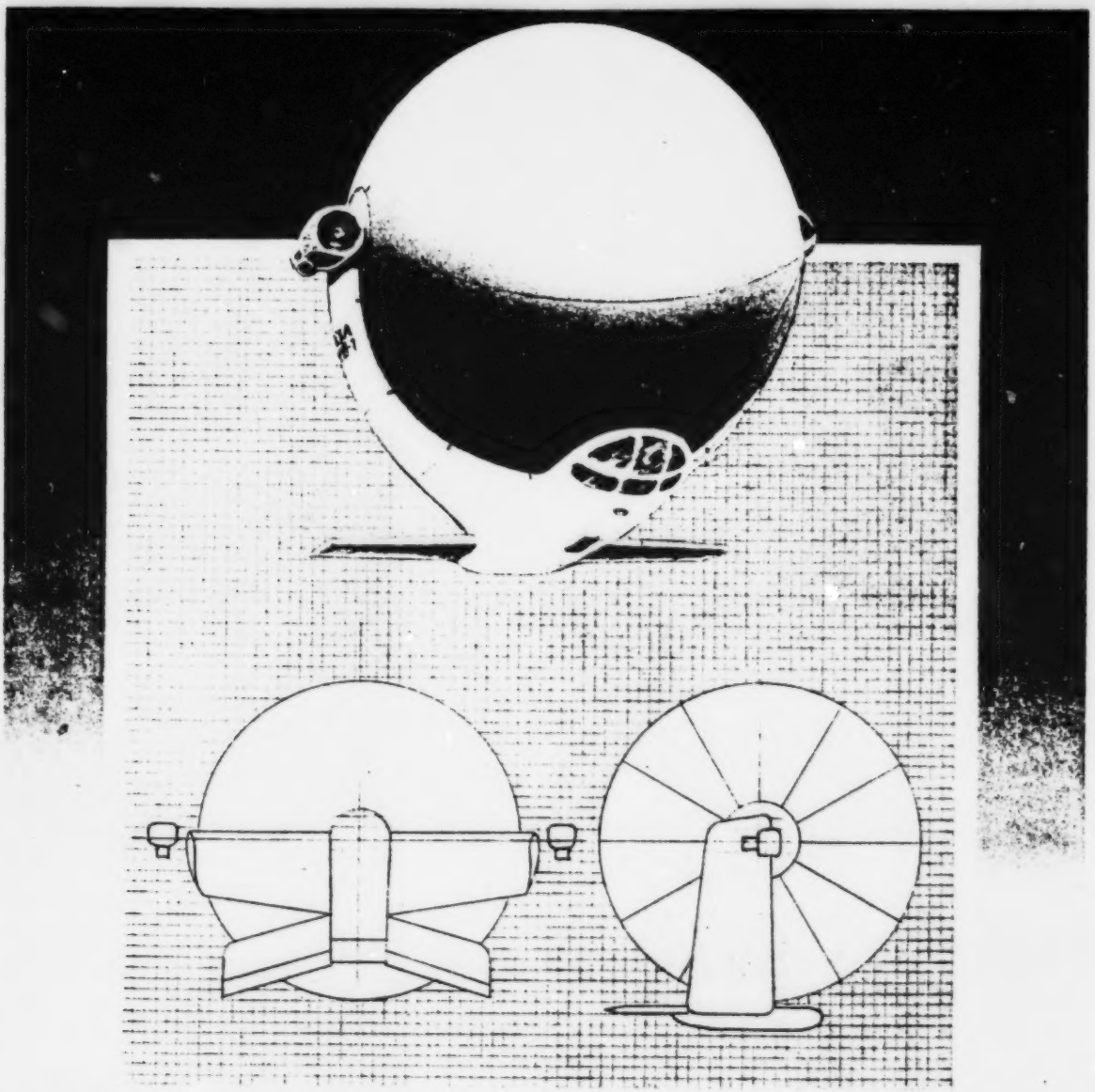
TP 7308E

Applications of the Magnus LTA Technology



Submitted to: Transport Canada
Research and Development

Prepared by: ADI Limited for:
Magnus Aerospace Corporation

March 1986

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FINAL REPORT

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Prepared for: Magnus Aerospace Corporation

by: ADI Limited

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17. Abstract

Nine case studies compare the LTA20-1 to existing transportation alternatives. These studies primarily involved transportation problems in Northern Canada where the existing transportation infrastructure is not particularly well developed.

It was determined that the LTA20-1 could be a viable alternative to existing transportation means in moving drill rigs into remote areas, moving pipeline materials across rivers where alternative means of crossing are not readily available, in fire fighting as a supplement to the Canadian CL-215 water bomber, for remote minining operations where annual production levels are low and possibly in material supply to northern offshore oil and gas drilling sites.

As a result of these case studies, two main markets for the LTA20-1 were identified: a) in missions where existing transportation alternatives impose economic penalties due to time delays, vehicle dimensions, payload right of way, seasonal restrictions or lack of existing infrastructure and b) in missions where transport alternatives do not exist at any cost. The first market is the one most immediately available to the LTA20-1 since it provides immediate economic benefits to the user. The second market is long range since this demand will not develop until the capability to supply it is first well established.

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APPENDIX A - OPERATING COSTS - HIGH AND LOW ESTIMATES

APPENDIX B - SUMMARY OF HLA LITERATURE

EXECUTIVE SUMMARY

Nine case studies compare the LTA20-1 to existing transportation alternatives. These studies primarily involved transportation problems in Northern Canada where the existing transportation infrastructure is not particularly well developed.

It was determined that the LTA20-1 could be a viable alternative to existing transportation means in moving drill rigs into remote areas, moving pipeline materials across rivers where alternative means of crossing are not readily available, in fire fighting as a supplement to the Canadian CL-215 water bomber, for remote mining operations where annual production levels are low and possibly in material supply to northern offshore oil and gas drilling sites.

As a result of these case studies, two main markets for the LTA20-1 were identified:

(a) in missions where existing transportation alternatives impose economic penalties due to time delays, vehicle dimensions, payload, right of way, seasonal restrictions or lack of existing infrastructure and

(b) in missions where transport alternatives do not exist at any cost.

The first market is the one most immediately available to the LTA 20-1 since it provides immediate economic benefits to the user. The second market is long range since this demand will not develop until the capability to supply it is first well established.

Some specific recommendations can also be made about the most suitable missions for the LTA 20-1.

1. In the case studies examined here the market is for the larger 30 and 55 tonne vehicles. While a smaller vehicle such as the 14-tonne version would be valuable as a demonstrator, its commercial applications would be limited to an aerial crane role. The 14 tonne LTA 20-1 is more efficient in the aerial crane role but the higher speed of a helicopter makes it more cost effective if it has to travel any distance.

2. The practical range limit for the LTA 20-1 is about 800 km. Beyond this distance the cost per tonne increases rapidly unless the vehicle can be refuelled. Below this range the LTA 20-1 is competitive with both helicopter and air cushion vehicles for the lower cost estimates used in the analysis.

3. The most promising applications for the LTA 20-1 are shuttle flights of 150 km or less where a large number of trips have to be made for a short duration project. The pipeline river crossing and the remote drill rig placement are good examples of this. Roundtrip distances are short, a large number of lifts are required and the duration of the projects does not justify construction of permanent rights-of-way. The LTA 20-1 offers cost savings in these roles for two reasons.

   (a) Lower cost vertical lift is an inherent property of the vehicle. This advantage can only be fully realized in short range missions where payload does not have to be traded off for fuel.

   (b) In short range shuttle flights the time required for pickups and drop offs becomes more important than cruise speed. The larger LTA 20-1 payloads mean 70% to 80% fewer pickups and drops then a helicopter.

4. A market for the LTA 20-1 exists in projects where there is a large delay cost associated with transportation time. The pipeline river crossing was the best example of this with an estimated delay cost of $220,000/day. Even though the LTA 20-1 is more costly than the trucks used to transport pipeline equipment, the overall cost of the move is lower with the LTA 20-1 due to the reduced delay charge.

5. The nature of the missions to which the LTA 20-1 is best suited are very often one-time requirements and it is unlikely that any one company will be able to fully utilize the vehicle for its own purposes over the vehicle's lifetime. The market for the LTA 20-1 would therefore be best approached through a third party operating company which would rent time to users as on "as required" basis.

The market for the LTA 20-1 vehicle in the short term will be for those missions where it produces immediate cost savings compared to alternative methods of transport. For the range of operating costs used these savings are produced in the short range missions.

The feasibility of using the vehicle in these missions will ultimately depend on a well defined operating cost and at present only a high and low cost estimate are available. Before these applications can be examined in any more depth the vehicle operating costs will have to be defined more closely. This in turn cannot be done until the vehicle itself is defined in detail and accordingly further analysis of these case studies should not be carried out until the vehicle definition is completed.

It is recommended that further, detailed analysis and evaluation be undertaken for those missions identified in this Phase 1 assessment as being potential applications for the LTA 20-1 after further vehicle definition is completed.

1.0 INTRODUCTION

1.1 Purpose and General Approach

The purpose of this study is to examine some potential applications for the Magnus Aerospace LTA 20-1 heavy lift airship (HLA), identify those which are the most promising and isolate the mission characteristics which make an application suitable to LTA 20-1 transport. Candidate missions selected are mainly located in Canada's north in resource development areas where existing transportation infrastructure is limited or non-existent.

The general approach is to compare the cost of LTA 20-1 transport to transport costs in various missions as they are now carried out. With the LTA 20-1 still in its development stage there is some uncertainty in estimating its operating costs. This has been overcome by using high and low operating cost estimates. The estimates, presented in Appendix A, are developed by using high and low values for fuel consumption, fuel price, insurance and initial cost.

1.2 Vehicle Description

The LTA 20-1 (figure 1.1) is a hybrid heavy-lift airship (HLA) which combines the buoyant lift of helium with rotor thrust to carry the vehicle's gross weight. The underlying principle of hybrid HLA vehicles is that all or nearly all of the vehicles empty structural weight is carried by bouyant lift leaving the rotors free to carry disposable payload. A helicopter, by comparison, uses its main rotor to carry both its own weight and the disposable payload. This results in an approximate twofold increase in disposable payload for the HLA without any increase in propulsive power as compared to a helicopter.

The vehicle analyzed in the case studies which follow is configured for heavy lift operation and has operating costs distinctly different from surveillance and patrol type applications. In surveillance and patrol

missions operating costs would be reduced in the order of 50% due to lower operating speeds and lift requirements.

The main features of the LTA 20-1 include:

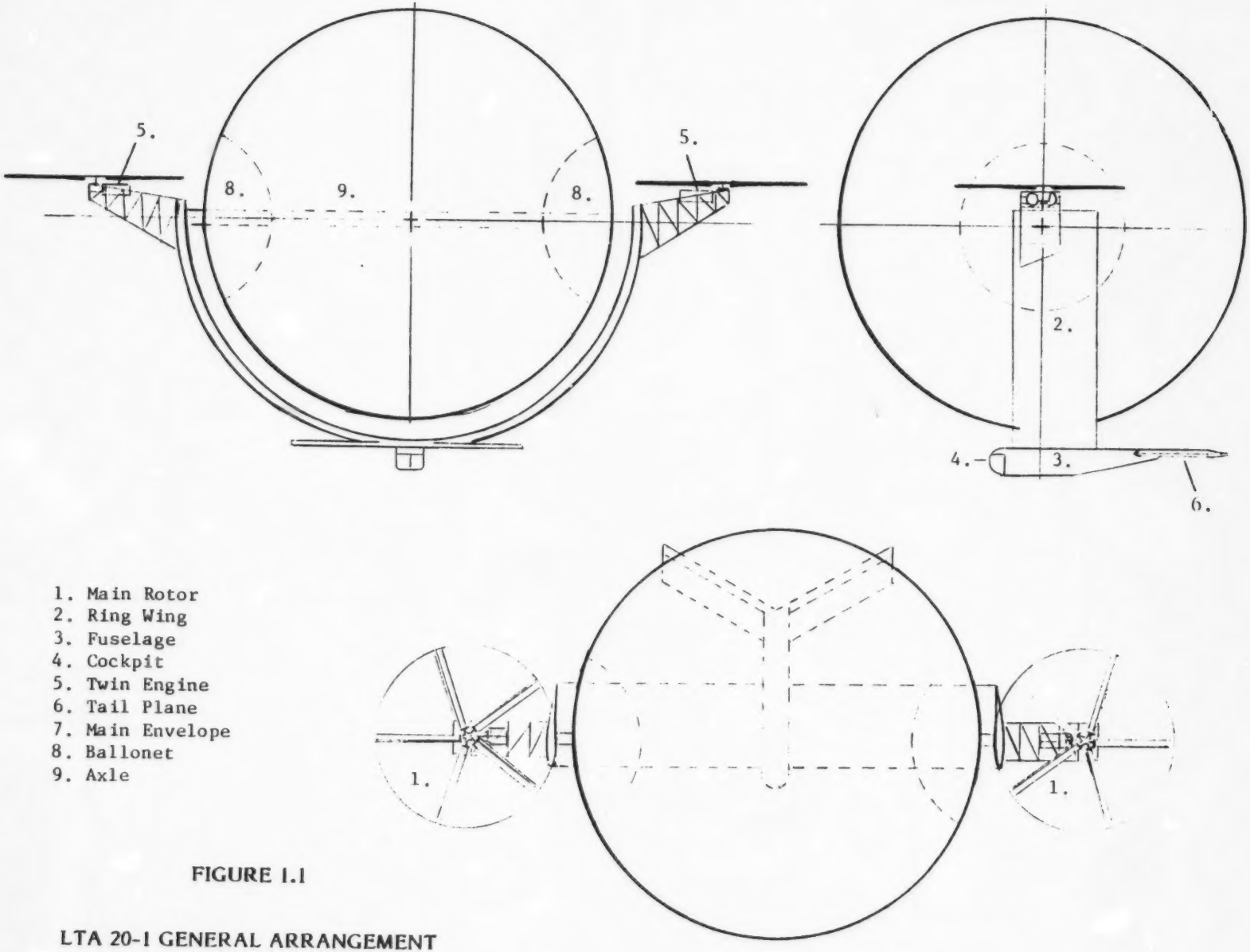
(a) Spherical envelope to contain the lifting gas - The spherical shape provides the least weight per unit of contained volume and is the most maneuverable shape for precision placement of heavy loads.

(b) Sphere rotation - The sphere is mechanically driven so as to rotate about a horizontal axis transverse to the direction of flight. This rotation uses the large surface area of the sphere to provide aerodynamic life from the magnus effect while in forward flight. The top of the sphere rotates with the free stream air flow and the bottom of the sphere is moving against it. This gives rise to a pressure differential and a wake deflection resulting in aerodynamic lift known as the magnus effect.

(c) Rotor systems mounted at either end of the transverse axis of the balloon - These rotors provide the lift to carry payload while hovering. They can also be vectored from the vertical position toward the horizontal to provide thrust for forward flight. As the rotors are vectored forward, lift that was provided by the rotors is now provided by aerodynamic lift from the Magnus effect and the lifting body of the fuselage structure and tail.

(d) The airframe consists of a ring wing separate from the sphere which joins the fuselage below the sphere to the axle/engine mounting point at the sides of the sphere. The fuselage provides the hardpoints for carrying slung loads or, alternatively unitized loads fastened rigidly to the airframe.

(e) The ballonet contained inside the main envelope is inflated or deflated with outside air in order to compensate for changes in the pressure of helium contained in the main envelope due to altitude or temperature.



1. Main Rotor
2. Ring Wing
3. Fuselage
4. Cockpit
5. Twin Engine
6. Tail Plane
7. Main Envelope
8. Ballonet
9. Axle

FIGURE 1.1

LTA 20-1 GENERAL ARRANGEMENT

1.3 Vehicle Specifications

Performance specifications have been derived for three different vehicles sizes using a parametric model prepared for this purpose.[1] The model calculates the variation in vehicle size and weight as payload capability is increased. Size and weight characteristics are combined with lift and drag parameters measured in wind tunnel testing[2] and are used to calculate vehicle performance. The results are summarized in Table 1.1. Most notable is the increase in payload from 14 to 55 tonnes possible with a relatively small increase in vehicle size: from 43 m to 49 m in diameter. This is possible because the main increase in weight which must be carried by buoyant lift is the weight associated with larger rotor systems. Figure 1.2 shows the payload/range tradeoffs for each vehicle.

In the 55 tonne configuration presented in Table 1.1 the entire disposable payload is carried in hover by thrust from the rotor systems. In earlier configurations of the craft a larger (60 m) diameter sphere was used in order that part of the disposable payload would be carried by buoyant lift and part by rotor thrust. While the previous configuration improved payload/range capability, it reduced versatility of the craft since ballast weight needed to be added each time the payload was dropped. It also had a much lower maximum speed due to the higher drag of the larger sphere. To obtain maximum versatility and speed it was decided to base the analysis on the latter design in which disposable payload is carried only by rotor thrust while hovering or by aerodynamic lift in forward flight.

TABLE 1.1

VEHICLE GENERAL SPECIFICATIONS

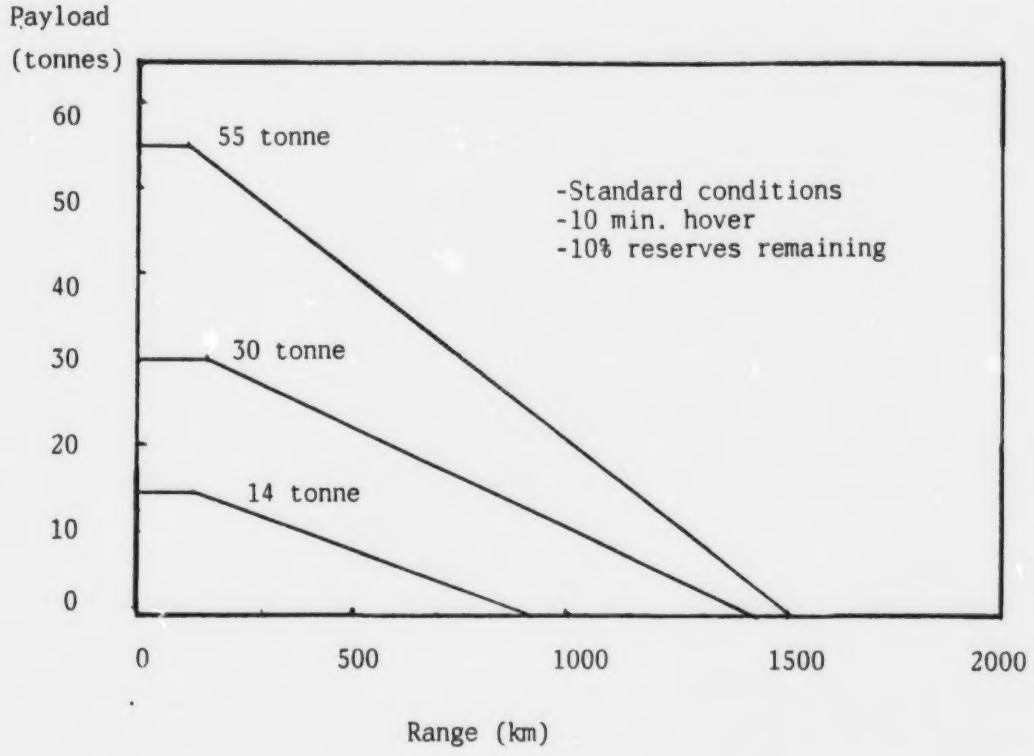
PAYLOAD:		14 tonnes	30 tonnes	55 tonnes
MAIN ENVELOPE:	Diameter	42.7 m	44.4 m	49.0 m
	Volume	40,764 m^3	45,829 m^3	61,600 m^3
PERFORMANCE:	Max. Speed	86 Kph	130 Kph	133 Kph
	Cruise Speed	57 Kph	82 Kph	90 Kph
	Range (1) @ Max Payload	118 Km/2.1 hrs	163 Km/2.0 hrs	187 Km/2.1 hrs
	@ Max Fuel	912 Km/15.8 hrs	1,449 Km/17.5 hrs	1,512 Km/16.8 hrs
VEHICLE WEIGHTS:	Gross Takeoff Weight	56,730 Kg	80,158 Kg	121,115 Kg
	Empty Operating Weight (EOW)	39,927 Kg	45,105 Kg	57,302 Kg
	Max. payload	14,000 Kg	30,000 Kg	55,000 Kg
	Max. Fuel @ 0 Pyld.	16,370 Kg	35,052 Kg	63,813 Kg
BUOYANCY RATIO	(Buoyant Lift/OEW)	95%	95%	95%
BALLONET CEILING:		1000 m	1000 m	1000 m
TAKEOFF/LANDING:		VTOL	VTOL	VTOL
ENGINES:		4xRR Gnome, 1660 SHP or 4xGE-CT58-140, 1500 SHP or 4xP&W-PW115, 1580 SHP (proposed shaft version)	4xGE-T64-413 @ 3,925 SHP	6xGE-T64-416 @ 4,380 SHP
ROTOR SYSTEM:		SIKORSKY S-61	SIKORSKY S-65	SIKORSKY S-65
CREW:		3	3	3
FUEL CONSUMPTION(2):	Max. Power	1768 L/HR	3966 L/HR	6501 L/HR
	Cruise	1060 L/HR	2379 L/HR	3900 L/HR

1. With 10 min. hover and 10% reserves remaining

2. Jet A 1.9 Lb/litre @ $^-20°C$

FIGURE 1.2

PAYLOAD/RANGE CHART



2.0 RELEVANT LITERATURE

While there are hundreds of references on all aspects of airship history and design, the three documents listed here are generally considered to be the most relevant studies on applications of heavy-lift airships in North America. Appendix B contains summaries taken directly from these reports:

(a) "Study of Civil Markets for Heavy Lift Airships," prepared by Booz-Allen Applied Research, Bethesda, Maryland for Ames Research Centre, NASA, December, 1978;

(b) "The Canadian Market for Heavy-Lift Aerial Vehicles," prepared by Aviation Planning Services, January, 1980;

(c) "Alberta Modern Airship Study," prepared for the Alberta Ministry of Transportation by Goodyear Aerospace Corporation, Akron, Ohio, June. 1978;

The Goodyear and Booz-Allen studies were positive towards heavy-lift airships while the APS findings were mostly negative. The APS study concluded that there are few single markets which can sustain full utilization of a large heavy lift airship (HLA). In acknowledging this point it appears that the market for HLA's will be through third party operators who lease time to users on an "as required" basis rather than through dedicated service by single users.

The APS study also found the economics of HLA's often did not compare favourably with existing transport alternatives. This is due in many cases to the assumption that there is an equally accessible transport alternative. In areas of underdeveloped transport infrastructure there is not always an economical alternative and the HLA and particularly the LTA 20-1 with its VTOL capability may provide a viable choice. Consequently this study focuses more on the unique characteristics of the LTA 20-1 and its application in missions where other transport alternatives do not exist or impose economic penalties on a project. The next eight chapters examine individual cases comparing the LTA20-1 to existing transport alternatives.

3.0 REMOTE DRILL RIG MOVE

3.1 General Description

This is a case study where the LTA 20-1 is used to replace helicopters for transporting oil rigs to remote locations. The movement of drilling rigs in the north poses a problem due to the lack of roadway infrastructure. Where roads are available, drill rigs are normally transported in 18,000 kg to 23,000 kg (40,000 lb. to 50,000 lb.) lots. In remote locations not served by roads, the weight of single pieces is limited by the helicopters which carry them. Drilling companies often move their equipment in 3,600 kg (8,000 lb) lifts typical of a Bell 214 helicopter. Operating costs for this helicopter are approximately $2,000.00/hr.(3)

Typical remote drilling operations establish a staging area next to the nearest barge landing, road or railway spur. According to the Alberta Modern Airship Study the average distance from the staging area to the drill site is 50 km.

The following equipment/supplies are moved by helicopter in 3,600 kg increments.(4)

(a) Drilling Rig

The rig is broken into 2-ton (1,818 kg) modules and requires 110 to 115 lifts.

Total: 440,000 to 460,000 lbs (199,637 to 208,711 kg).

(b) Drill Pipe

Total quantity required:

- 500 lengths drill pipe and drill collar .114 m
  9.35 m (30 foot) length - each 227 kg (500 pounds)
  Total: 113,430 kg (250,000 pounds)
- 40 drill joints - each 1,815 kg (4,000 pounds)
  Total: 72,595 kg (160,000 pounds)

(c) Drill Casing

- 914 to 1,219 m (3,000 to 4,000 foot) casing -
  weight: 80 kg/m (54 pounds/foot).
  Total: 72,595 to 99,818 kg (160,000 to 220,000 pounds).
- 3,200 m (10,500 foot) x .24 m (9-5/8 inch) casing -
  weight: 47 kg/m (32 pounds/foot)
  Total: 152,400 kg (336,000 pounds)
- 4,267-4,572 m (14,000-15,000 foot) x .2 m (7-7/8 inch) casing
  weight: 43 kg/m (29 pounds/foot)
  Total: 183,707-197,314 kg (405,000-435,000 pounds)

(d) Fuel

The drill jig consumes 13.6 kg (30 pounts) fuel per day. and the total time of operation is 45 days up to 120 days. The fuel is brought to the site in a rubber bladder. Weight of the bladder is 113 kg (250 pounds) empty and holds 1,814 kg (4,000 pounds) of fuel and the total weight is 1,928 kg (4,250 pounds).

(e) Crane

A 5,000 lb (2,268 kg) capacity crane is brought onto the site. The crane weighs approximately 8,000 lbs (3,629 kg).

3.2 Cost of Helicopter Transport

The total weight to be transported by helicopter is between 799,619 kg and 849,387 kg. The helicopter makes between 222 to 236 round trips.

When drilling is concluded the rig and crane have to be transported out again. This will require another 56 to 59 lifts resulting in total project lifts of 278 to 295 lifts.

Each lift will average 45 minutes flying time at a transportation cost of between $417,000 and $442,500.

In addition to the direct costs of the helicopter there is a standby charge of $28.950 to $38,600 per day for the drill crew and services while the drill rig is out of commission. In 3,600 kg lifts the helicopter will take 5 days to move the drill rig incurring a standby charge of $160,000. The same charge will apply when the rig is removed. (Note there is no standby charge while the rest of the equipment is being moved).

The total cost for the helicopter, personnel and services is approximately $740,000.

3.3 Cost of LTA 20-1 Transport

The LTA 20-1 can complete the move to and from the site in 30 tonne increments in less than 5 days. Using the LTA 20-1 vehicle with the 30 tonne payload the following number of lifts are required:

1. Drill rig: (fuel and crane would be carried during one or more of these lifts) - 9 lifts, 22 tonnes each.

2. Drill pipe: 4 lifts (28.4 tonnes each)

3. Drill joints: 3 lifts (24.2 tonnes) includes remainder of drill pipe.

4. Drill casings: 14 lifts of 30 tonnes*

5. Return drill rig: 9 lifts, 22 tonnes each.

At 1 hour per lift the low estimate for the LTA 20-1 is $149,916 and the high estimate is $276.978. The standby cost for 5 days are $160,000 and the total cost for the move using the LTA 20-1 at the low estimate is $310,000 and at the high estimate is $437,000. High and low estimates are based on hourly operating costs developed in Appendix A.

* Any overweight requirement would be absorbed in the drill joint lifts.

3.4 Conclusions

The cost of the drill rig move is:

LTA 20-1 low estimate -	$310,000
LTA 20-1 high estimate -	$437,000
B-214 helicopter	$740,000

The LTA provides a good margin even at the high estimate. Savings can be realized both in the direct transport costs and in standby time for the drill crew.

Higher payload capacity also makes it possible to use larger heavier rigs at remote sites. The rigs designed to be flown in small pieces are about 20% more expensive than normal rigs, take longer to set up and are not sturdy enough to be used again in southern markets.

4.0 PIPELINE CONSTRUCTION - RIVER CROSSING

4.1 General Description

There are approximately twenty river corssings on the Canadian Foothills portion of the pipeline that required circuitous routing of construction equipment to transport to the ROW (Right of Way) on the opposite river bank. Bridges proved cost-prohibitive and time-ineffective. Therefore equipment was transported from the completed ROW to the first existing road that lead to a suitable crossing. Once across the river, the first existing road back to the ROW site was taken. The circuitous routing one-way distance varied from 32 km to 209 km. An average one-way distance of 121 km will be considered for the purpose of this analysis. In some cases new roads had to be built while in other cases the existing road infrastructure was sufficient. In reality, 20% of the total overland distance required new roads.

The figures used for the analysis are based on discussions with Lavilin Construction.(5)

4.2 Cost of the Move by Truck Transport

The cost of a river crossing as it is currently done includes a positioning charge for the trucks, the transport cost across the river and the crew standby charge while the pipe laying operations is delayed. The cost of these components is estimated as follows:

(a) Positioning charge

- assumed round trip distance - 600 km
- unit cost $1.45/km (6 axle semi-trailer)
- 10 trucks
- positioning charge = 600 km x $1.45/km x 10 trucks
  = $8,700

(b) Transport Cost to Cross the River

- unit cost - $75/hr/truck
- loaded distance - 121 km/trip
- average loaded speed - 50 km/hr
- time for loaded haul - 2.42 hr
- average unloaded speed - 30 km/hr
- time for empty return - 1.51 hr
- load/unload time - .5 hr
- total time/trip - 4.43 hr/trip
- total trips required is approximately - 91 trips
- transport cost = 91 trips x 4.43 hr/trip x $75/hr
  = $30,235

(c) Standby Charge

- Using 10 trucks to perform 91 trips at 4.43 hr/trip the time to transport the equipment is 40.3 hrs.
- Assuming the move can be performed in a 48 hr priod, and some of the pipline crew will be involved in the move and resume construction before all the equipment has been moved then the standby charges are based on one lost 10-hr shift per crew member.
- With an average 550 men in a crew at $40/hr the standby charge is:
  = 550 x 10 hr x $40/hr
  = $220,000

The total cost of the river crossing using trucks is $258,935.

4.3 Cost of the Move by LTA 20-1 Transport

The 55 tonne LTA 20-1 offers approximately the same payload capacity as the trucks and on this basis the same number of trips (91) is assumed.

Movement of equipment by the LTA 20 would not require precision placements. Based upon hook-up and release times for helicopters for non-critical pickup and placement of equipment and a round trip distance of one mile. 7 trips/hour is felt to be realistic.

The total cost of the move again includes a positioning charge, transportation cost and a standby charge.

(a) Positioning Charge

- assumed round trip distance - 400 km
  (straight line distance = 2/3 of road distance)
- cruise speed - 90 kph
- time - 4.44 hrs
- positioning charge: low - $25,472
  high - $51,064

(b) Transport Cost

- unit cost: low - $5,737/hr
  high - $11,501/hr
- Time: 91 trips/(7 trips/hr)
  13 hrs
- Transport Cost: low - $74,581
  high - $149,513

(c) Standby Charge

The majority of the move can be performed in one 10 hour shift and will involve the entire crew. On this basis there is no lost time due to the move.

The total cost for the move using the LTA 20-1 is $100,053 at the low estimate and $200,577 at the high estimate.

4.4 Conclusions

The costs of the move are:

Truck	$258,935
LTA 20-1 low estimate	$100,053
LTA 20-1 high estimate	$200,577

The LTA 20-1 can provide cost savings of 20% to 60% for the river crossing. The savings are not a result of direct transportation costs but stem from the reduced standby charge for the pipeline work crew.

This analysis points to a more general market for the LTA 20-1 in situations where the cost of downtime due to transportation requirements is high. While the direct transportation costs of the LTA 20-1 may be higher then the existing alternative, it is still justified in view of the total cost.

5.0 FIRE FIGHTING - WATER BOMBER

5.1 General Description

When a fire is first spotted the normal approach is to dispatch a 5 man crew to the sight, usually by helicopter to put out the fire while it is still small. If this crew is not successful then a water bomber attack together with ground crews and equipment are called in to fight the fire. The LTA 20-1 could play a useful role both as a water bomber and in moving men and equipment to the fire scene. The water bomber application is analyzed here.

5.2 Approach to the Analysis

The approach to the analysis is to compare the LTA 20-1 with the Canadair CL-215 water bomber on the basis of cost per tonne of water delivered to the fire. While the LTA 20-1 is able to deliver about 3 times as much water per hour as a CL-215 this factor is discounted since it is always possible to add additional CL-215 aircraft to make up this difference without changing cost/tonne.

It is also assumed the CL-215 will remain as the first line of response after the 5 man initial response crew. The 300 kph cruise speed of the CL-215 allows for a more rapid response from the fixed base of operation to the fire scene, an important factor in catching a fire before it grows. The LTA 20-1 would provide the next line of defense by providing high capacity and more accurate water application.

The analysis assumes the distance from the lake to the fire to be 5 km one way. This is typical of timber forests in Northern Ontario shield area. Response time from the fixed base of operations to the fire will also affect costs. The CL-215 must be based at runways of approximately 1,370 km (4,500 ft) in length while the LTA 20-1 does not require an airstrip and may be stationed at any strategic location. For this analysis it is assumed that response costs are equal. In practice the

slower LTA 20-1 would require a shorter response distance in order to equal the cost of the CL-215.

5.3 Conventional Water Bomber - Operating Costs

General specifications of the Canadair CL-215 water bomber are as follows:(6)

Capital Cost	$6.5 million
Operating Cost	$1,500.00/hr
Gross Weight	19,731 Kg
Payload	5,433 Kg
Endurance	3.5 hrs
Cruise Speed	202 kph
Water Takeoff Dist.	1,200 m

Unit Cost Calculations

Lake/fire	round trip distance	10 km
	cruise speed	300 kph
	cruise time	2 min.
Approach/take off/circling		3 km
	speed	170 kph
	time	1.06 min.
Total Cycle Time		3.06 min
Productivity (19.6 trips/hr		
	x 5.4 tonnes/trip	106 tonnes/hr
Cost/tonne of water delivered		$14.15/tonne

5.4 LTA 20-1 Water Bomber - Operating Costs

The comparable specifications for the LTA 20-1 are:

Operating cost	- high estimate - $11,501/hr
	- low estimate - $ 5,737/hr
Average Payload	45 tonnes
Endurance	5.0 hours
Cruise speed	100 kph
Water takeoff	VTOL

For the unit cost calculations there is no approach/takeoff/circling distance but there is a component of time associated with water pickup and drop off. An adjustment factor of 1.3 has also been applied to the water delivered by the LTA 20-1 to reflect more accurate placement of loads possible at lower speed. Unit cost calculations follow:

Lake/	fire roundtrip	10 km
	max cruise speed	100 kph
	cruise time	6.7 min.
Water pickup and drop time		0.5 min
Cycle time		7.2 min
Productivity (8.33 trips/hr		
	x 45 tonnes/trip)	375 tonnes/hr
Effect of more accurate water		
placement 1.3 x 375		487 tonnes/hr
Cost/tonne of water delivered		
	- low	$11.80/tonne
	- high	$22.60/tonne

5.5 Conclusions

The costs/tonne of water delivered to the fire are:

LTA 20-1	low	$11.80/tonne
LTA 20-1	high	$22.60/tonne
CL-215		$14.15/tonne

At the low estimate the LTA 20-1 is competitive with the CL-215. The main advantage associated with the LTA 20-1 is its flexibility to locate near trouble spots where fire danger is high in order to reduce response time. For example CL-215's located 500 km from a fire would take 1 hour and 40 minutes to respond while an LTA 20-1 base located 100 km from the fire can respond in 1 hour. The LTA 20-1 is also able to land at virtually any size of water body while the CL-215 requires about 2,000 m of clear water for approach, water-fill and takeoff.

The LTA 20-1 can also offer a longer endurance possibly working all day at the fire location without having to refuel.

The advantage of the LTA 20-1 over the CL-215 will increase as the distance between the lake and the fire is reduced. On this basis it can be concluded that the best market for this application lies in Canadian shield timber forests where there is a high frequency of lakes.

The LTA 20-1 also allows for more accurate placement of water drops. If the water drops from the LTA 20-1 were twice as effective as the CL-215 for example this would reduce the effective cost/tonne to $7.71/tonne for the low and $9.20/tonne for the high cost estimate.

6.0 REMOTE COMMUNITY SUPPLY

6.1 General Description

In this analysis the LTA 20-1 will be compared to conventional fixed wing aircraft in an actual case experienced by DIAND.[7] A Hercules aircraft was hired to move equipment from Thunder Bay to three remote communities in the James Bay/Hudson Bay area. Eight pieces of equipment were carried in a total of nine trips with the maximum single load being 14 tonnes. In this situation the equipment would not fit into smaller aircraft and larger aircraft could not land at the existing runways. The equipment was being shipped from Thunder Bay to Fort Severn on Hudson's Bay, and to Webequie and Big Trout Lake which are Indian communities in Northern Ontario west of James Bay.

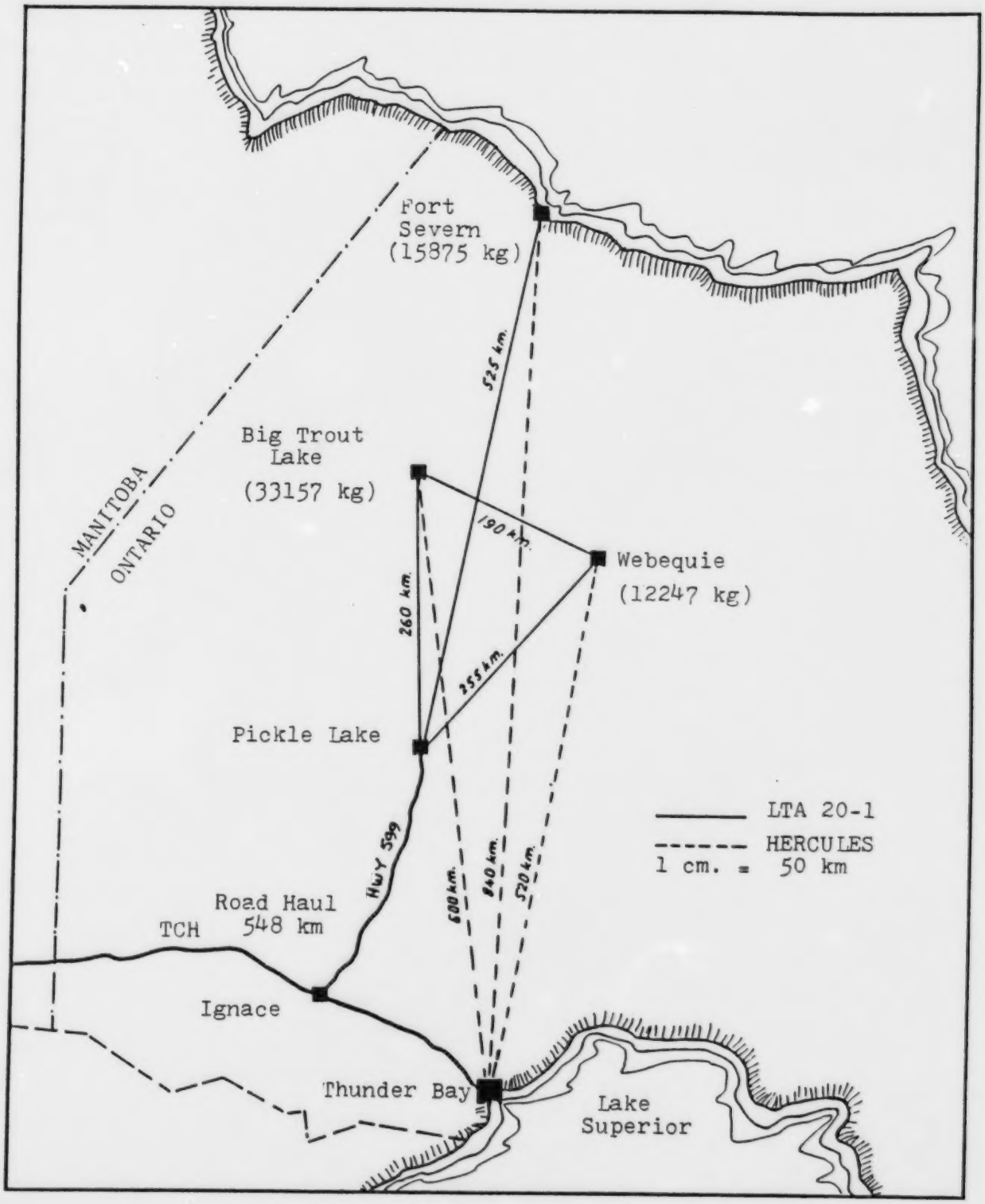
This situation is representative of the case where existing transport systems impose economic penalities on a project due to the constraints on the transport vehicles.

6.2 Approach to the Analysis

The Hercules transport is compared to LTA 20-1 on a purely cost basis. The Hercules must fly out of Thunder Bay due to gross weight/field length requirements. The LTA 20-1 is assumed to fly out of Pickle Lake to the remote communities with the loads transported by road to Pickel Lake from Thunder Bay. Figure 6.1 shows the distances and location of the communities involved.

FIGURE 6.1

MISSION PROFILE
REMOTE COMMUNITY SUPPLY



6.3 Hercules Air Transport Costs

The commercial rate used initially for transporting the equipment was $6.524/km plus fuel cost for the L-100-30 Hercules and crew. The equipment was eventually carried by a military Hercules since the commercial carrier was not able to provide the service, however, the commercial rate is used in this analysis since it is presumed to reflect the true cost of operation.

The commercial rate was estimated in Table 6.1 to be $91,115 excluding the positioning charge. A fuel price of $.50 per litre was used since the Hercules can fill up at Thunder Bay and make a complete round trip before refuelling.

6.4 LTA 20-1 Transport Costs

In the LTA 20-1 transportation scenario the equipment is transported first from Thunder Bay by road to Pickle Lake where it is transferred to the LTA for transport on to final destinations. The equipment weights were as follows:

Fort Severn	Loader	7,711	Kg
	Truck	4,536	
	Float trailer	3,629	
		15,876	
Webequie	Loader	7,711	Kg
	Truck	4,536	
		12,247	
Big Trout Lake	Excavator	17,236	Kg
	Bucket	544	
	Motor Grader	14,016	
	Ambulance	1,360	
		33,156	

TABLE 6.1

ESTIMATED HERCULES CONTRACT PRICE

1.	Destination	Fort Severn	Webequie	Big Trout Lake
2.	Round Trip Dist (km)	1,680	1,040	1,200
3.	Cruise Speed	500	500	500
4.	Duration @ (kph)(hrs) 500 kph cruise	3.36	2.08	2.4
5.	Avg. Cruise (lb/hr) Fuel Flow (130,000 Lb. G.W. Std. Day, 14,000 ft)	3,600	3,600	3,600
6.	Cruise fuel (Lb)	12,096	7,488	8,640
7.	T/O, Landing fuel (Lb)	1,000	1,000	1,000
8.	Total Fuel (Lb)	13,096	7,588	8,740
9.	Fuel Charge @ $.263/lb ($.50/l)	$ 3,444	$ 1,996	$ 2,299
10.	Distance Charge @ $6.52/km	$10,954	$ 6,780	$ 7,824
11.	Cost/trip	$14,398	$ 8,776	$10,123
12.	No. of Trips	3	2	3
13.	Total Cost	$43,194	$17,552	$30,369

Total $91,115.00

The truck leg is 548 km from Thunder Bay to Pickle Lake. The loader, float trailer and single axle dump truck for delivery to Webequie can be driven to Pickle Lake as a self-contained unit. The remaining equipment can be delivered on 3 flatbed tractor trailers. The total cost of the truck leg is estimated as follows:

-	Drive single axle dump truck with float and loader to Pickle Lake 548 km x $.87/km	$ 477
-	Driver return with no truck	200
-	3 Tractor trailers x 548 km one way x 2 x $1.45/km	4,768
-	Expenses	250
		$ 5,695

Using the 55 tonne payload vehicle the equipment can be transferred from Pickle Lake to the final destinations by the LTA 20-1 in two lifts. The first lift including all the equipment bound for Webequie and Big Trout Lake (total 45,404 kg) is carried out in three legs:

1st Leg - Pickle Lake to Webequie

Distance - 255 km

Block Speed - 85 km/hr

Cruise Time - 3.0 hrs

Fuel Consumption: low at 3,000 l/hr = 9,000 l
high at 4,005 l/hr = 12,015 l

Unload and refuel at Webequie time = .5 hr.

Remaining payload - 33,157 Kg

2nd Leg - Webequie to Big Trout Lake

Distance - 190 km

Block Spped - 85 km/hr

Cruise Time - 2.23 hr.

Fuel Consumption: low at 3,000 l/hr = 6,690 l
high at 4,005 l/hr = 8,931 l

Unload at Big Trout Lake - time = .5 hr.

3rd Leg - Big Trout Lake to Pickle Lake

Distance - 260 km

Block Speed - 85 km/hr

Cruise Time - 3.06 hr

Fuel Consumption: low at 3,000 l/hr = 9,180 l
high at 4,005 l/hr = 12,255 l

Using unit costs from Appendix A the total cost for the first lift is:

	Low	High
Total time charge for 9.29 hrs	$39,361	$ 51,030
Fuel: 1st leg @ .50/l	4,500	$ 6,007
2nd leg @ $1.00/l	6,690	8,931
3rd leg @ $1.00/l	9,180	12,255
Total for first lift:	$59,731	$ 78,223

The second lift would carry 15,875 Kg to Fort Severn and return unrefuelled to Pickle Lake. The roundtrip distance is 1,050 km which lies just within the payload/range curve at a payload of 15.8 tonnes for the 55 tonne vehicle. The cost for this lift is as follows:

Distance - 1,050 km

Block Speed - 90 km/hr

Fuel Cost - $.50/l

Cruise Time	11.67	hrs
Unload time	.60	hrs
Total Time	12.27	hrs

	Low	High
Time Cost	$ 51,988	$ 67,399
Fuel Cost	$ 18,045	$ 24,570
	(@ 3,000 l/hr)	(@ 4,005 l/hr)
Total Cost for 2nd lift	$ 70,393	$ 91,969

Total cost for the two lifts and the trucking from Thunder Bay to Pickle Lake is:

	Low	High
Trucking	$ 5,695	$ 5,695
Lift No. 1	$ 59,731	$ 78,223
Lift No. 2	$ 70,393	$ 91,969
	$ 135,819	$ 176,217

6.5 Conclusions

The cost of the LTA 20-1 exceeds the cost of the Hercules under these conditions of load and routing. In order to realize the benefits of LTA 20-1 transport in remote community supply the missions need to be short range, multi-stop trips. particularly to sites where airstrips are short or non-existant. The Hercules payload, for example, is restricted to payloads of about 9 tonnes with landing lengths of 1,067 m (3,500 ft) and cannot land at all with lengths much below 900 m (3,000 ft). The most likely market for remote community supply are those communities without road or airstrip and now served by float or ski planes carrying 2 to 3 tonnes of payload.

7.0 MINE DEVELOPMENT - CONTWOYTO LAKE

7.1 General Description

Contwoyto Lake is situated about 350 km North of Yellowknife on Great Slave Lake. Five potential mine sites have been identified in the vicinity of the lake but currently there is no road access to the area. The Department of Indian and Northern Affairs is examining options for access to the area including various combinations of winter road, all weather road and barge.(8)

The mines include some precious metals which may only yield a small annual production volume of concentrate. This situation makes it difficult to economically justify roadway construction but may lend itself to the more flexible heavy lift airship alternative.

7.2 Approach to the Analysis

The approach to evaluating the LTA 20-1 in this role is to establish a breakeven production level between transportation alternatives. Below a certain production level the LTA 20-1 would be less costly and above this level, investment in surface transport infrastructure is more economical.

The cost per tonne of each alternative is established as a function of annual production volume. Equating the cost of one alternative to the other and solving for the production volume gives the breakeven point in tonnes/year.

7.3 Surface Transport Cost/Tonne

Winter Road

The cost of opening and maintaining a winter road across frozen lakes and tundra varies with terrain between $1,500 and $2,000/km. For this analysis a representative cost of $1,800/km is assumed. The proposed route is 750 km between Yellowknife and the furthest mine site.

Vehicle Characteristics

Winter ice roads are typically opened to traffic when they will support a gross vehicle weight of 20 tonnes. As the ice thickens gross weights can be increased up to 60 tonnes. Empty weight of a 5-6 axle tractor trailer bulk carrier is 14.5 tonnes leaving a maximum available payload varying from 5.5 to 45.5 tonnes. An average value of 35 tonnes is assumed for the analysis.

Vehicle operating costs are taken from the 1984 Trimac Report[9] assuming 160.000 km annual distance, gravel roads, winter operation, bulk carrier and operation in N.W.T. The unit operating cost is $1.45/km.

Transportation Cost per Tonne by Truck

The transportation cost per tonne includes the fixed cost for opening the winter road each year and the variable cost of the transport truck. The cost of terminal handling is excluded since it is assumed to be approximately equal regardless of alternative. The cost is expressed as a function of annual production level of the mine.

$$\text{Cost/Tonne} = \frac{\text{Annual Road Cost/km x distance}}{\text{Annual Production (tonnes)}} + \frac{\text{Truck Cost/km x Roundtrip dist (km)}}{\text{Truck payload (tonnes)}}$$

$$= \frac{\$1{,}800/\text{km} \times 750 \text{ km}}{V} + \frac{\$1.45/\text{km} \times 750 \text{ km} \times 2}{35 \text{ tonnes}}$$

$$= \frac{(1{,}350{,}000 + 62.14)}{V} \ \$/\text{tonne}$$

Where V = annual mine production volume (tonnes)

7.4 LTA 20-1 Transport Cost/Tonne

The air distance between Yellowknife and the furthest Contwoyto Lake mine site is 350 km or 47% of the road distance. With the round trip distance of 700 km the payload of the 55 tonne LTA 20-1 vehicle will be reduced to 33 tonnes in order to accommodate extra fuel load.

The cost per tonne of payload for the LTA 20-1 is:

$$\text{cost/tonne} = \frac{\text{Direct Operating Cost x Distance}}{\text{Cruise speed x Payload}}$$

$$= \frac{\text{DOC} \times 700 \text{ km}}{90 \text{ km/hr} \times 33 \text{ tonnes}}$$

$$= \text{DOC} \times .236$$

Using the high and low DOC's for the 55 tonne vehicle from Appendix A the delivered cost/tonne is:

low = \$5,737/hr x .236
= \$1,354/tonne

high = \$11,501/hr x .236
= \$2,714/tonne

7.5 Breakeven Volume

The breakeven volume is the annual production volume at which the cost per tonne for LTA 20-1 transport equals the cost per tonne for building the ice road and operating trucks.

LTA Cost/tonne = Surface Transport Cost/tonne

and for the low LTA operating cost estimate:

$1,354/tonne = ($1,350,000/V +62)/tonne

V = 1,045 tonnes/yr

and for the high operating cost estimate:

$2,714/tonne = ($1,350,000/V +62)/tonne

V = 509 tonnes/yr

7.6 Conclusions

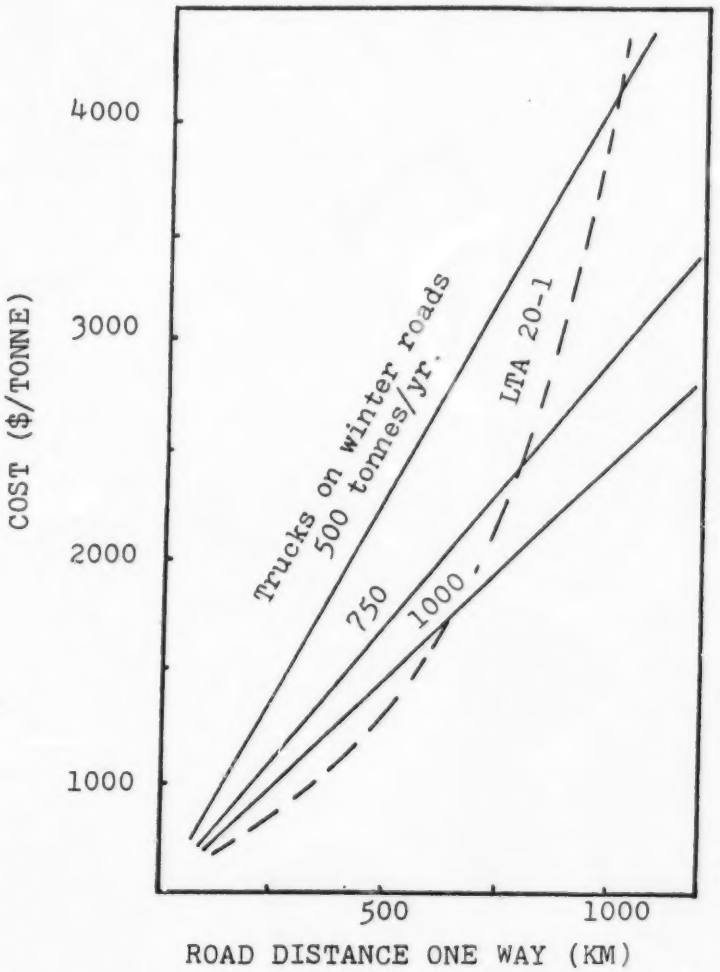
Using the low LTA Operating cost estimate the LTA 20-1 would be more cost effective then building ice roads at mine concentrate production levels below 1,045 tonnes/yr. At a transportation cost of $1,354/tonne this precludes transporting any low value product but would allow otherwise inaccessible small pockets of high value precious metals to be retrieved.

A graph of transport cost v.s. distance for annual transported volume is shown in figure 7.1. This figure plainly shows how the market for the LTA 20-1 lies in the shorter range.

FIGURE 7.1

COST/TONNE

LTA 20-1 V.S. TRUCK ON WINTER ICE ROADS



Trucks on Winter Roads

LTA 20-1

8.0 MACKENZIE RIVER FERRY CROSSING

8.1 General Description

The Dempster Highway is the main highway linking Southern Canada to Inuvik and Tuktoyaktuk, which is the staging area for much of the Beaufort Sea and Arctic Islands activity. Traffic on this highway crosses the Mackenzie River at the Arctic Red River Community by means of ice bridge in winter and by ferry in summer. For 3-4 weeks in the spring and 6-8 weeks in the fall there is no link available for the highway. 1984 Records from the ferry operated in summer show average daily traffic varying from 1,590 veh/day in October to 3,395 veh/day in June.

The role of the LTA 20-1 in this scenario is to provide ferry service on specified days of the week during spring breakup and fall freeze-up.

8.2 Cost of LTA 20-1 Transport

At the point where the Dempster Highway meets the Mackenzie, the river is approximately 1 km wide. The average crossing time would be about 2 minute for the LTA. Allowing 5 minutes to load and 4 minutes to unload the LTA 20-1 could make 5 crossings per hour with a 5 minute margin each hour.

Using a 55 tonne payload vehicle and a load pallet weighing 10 tonnes the LTA 20-1 can carry up to 45 tonnes of vehicles. This is equivalent to a single loaded tractor-trailer, or 3 empty tractor-trailers or 30 cars. During one 8-hour period the LTA 20-1 could carry 6 loaded and 8 empty tractor trailers and 900 cars.

Using the high and low estimates for the LTA 20-1 operatin cost then the equivalent ferry costs per vehicle would be:

	Low	High
Automobile	$ 38	$ 76
Tractor-Trailer Empty	382	766
Tractor-Trailer Loaded	1,147	2,300
Loaded Trailer Only	574	1,150

8.3 Conclusions

During the spring and fall periods there is currently no alternative for vehicles to cross the Mackenzie. A 25 tonne capacity air cushion vehicle may be brought into service for this purpose but is still not able to accommodate most loaded tractor trailers.

Providing the LTA 20-1 ferry service during spring and fall would add about $2,000 to truck rates of $7,000 from Edmonton to Inuvik.(10)

The alternative is truck to Dawson for about $4,000/truck and charter aircraft to Inuvik at a cost of about $6,000. On the basis of available alternatives the LTA 20-1 ferry service is viable, however, it is more likely that shippers will advance or delay shipments to avoid the spring and fall periods.

Since the hovercraft would provide lower cost transport for cars while trucks are more likely to avoid the spring and fall periods the market for the LTA 20-1 in this application is limited.

9.0 ARCTIC COMMUNITY RESUPPLY

In this role it was originally intended to investigate the LTA 20-1 as a supply vessel for Arctic Island and north shore communities, replacing marine vessels which now serve this role. The analysis of the LTA 20-1 in Northern Ontario community supply and the mine development scenarios have shown the costs per tonne increase very rapidly at distances over 800 km due to payload/range tradeoffs. Since the distance to most western Arctic communities from the main staging area at Tuktoyaktuk is equal to or greater than this distance the LTA 20-1 would not be competitive with existing methods.

10.0 RESUPPLY OFFSHORE OIL AND GAS WELLS

10.1 General Description

One of the drilling sites planned by Gulf in the Beaufort is located about 80 km (50 mi.) offshore from Tuktoyaktuk.(11) Winter ice roads are not practical at this site. The alternatives now under consideration for supplying the site are supply vessels operating during the navigable season, a class 6 icebreaker capable of operating year round and the recently arrived air cushion vehicle "Larus" operated by Arctic Transportation Ltd. The location lies within the range of helicopters but the annual volume of supplies required makes this option uneconomical.

Gulf is currently studying the tradeoffs between the cost of providing onsite storage facilities replenished during the navigable season and the cost of providing year round supply.

In this role the LTA 20-1 would be operating in a point-to-point service over a short range with high volumes. The cost of providing expensive on-site winter storage at the drill site may be avoided by using the LTA 20-1 in the winter months and supply vessels in the navigable season. The nivigable period for the Arctic Coast is approximately 72 days.

10.2 LTA 20-1 Supply Scenario Cost

In the LTA 20-1 supply scenario supplies would be brought to the drill site by supply vessel for 72 days of the year while the water is open. The LTA 20-1 would be used during the remaining 293 days of the year. A total annual volume of 80,000 tonnes per year is assumed. consisting mainly of drill pipe and chemicals. The cost of this operation is estimated as follows:

(a) Supply Vessel

- Assuming supplies are distributed evenly over the year the supply vessel would deliver 15,781 tonnes during the navigable season.
- Cost of a 1,000 tonne payload supply vessel making 16 one day trips at $50,000/day = $800,000.

(b) LTA 20-1

- Balance of supplies delivered over the remainder of the year is 64,219 tonnes
- Assume the vehicle is operational for 235 days or 80% of the 293 days when the supply vessel is not used. This requires a delivery rate of 274 tonnes/day which can be achieved in 6 round trips/day.
- Time to complete 6 round trips is 11.7 hours assuming 160 kph round trip distance, 90 kph cruise and 10 min. load/unload time.
- High and low cost estimates for the LTA 20-1 are:

	Low	High
Cost/hour	$5,737/hr	$11,501/hr
Cost/tonne	$ 245/tonne	$ 491/tonne
Cost for 64,219 tonnes	$ 15.7 million	$ 31.5 million

(c) Total Cost for 80,000 tonnes

	Low	High
Supply Vessel	$ 800,000	$800,000
LTA 20-1	$ 15.7 million	$ 31.5 million
	$ 16.5 million	$ 32.2 million
Average Cost/tonne	$ 206/tonne	$ 404/tonne

10.3 Alternate Supply Scenarios

Air Cushion Vehicle - Assuming a 25 tonne payload, cruise speed of 36 kph and operating cost of $2,000/hr average cost of delivery during the period when the supply vessel cannot be used is $396/tonne and would require a fleet of 5 to 6 vehicles to meet daily requirements.

Class 6 Icebreaker Supply Vessel - Assuming a 1,000 tonne payload, one day to complete a roundtrip and an operating cost of $90,000/day the average cost of delivery is $90/tonne. The icebreaker would provide the lowest cost per tonne based on these assumptions but would have to be used to serve other markets as well since these assumptions account for only 80 days/year. The icebreaker at $100 million first cost is also the most capital intensive option.

Summer Delivery with Stockpiling - There is no cost estimate for creating extra storage space at the drilling location to store consumables over the winter season. Based on the foregoing analyses however the incremental cost of this option would have to be less than $3.2 million. This is the difference between the lowest year-round supply scenario ($90/tonne x 80,000 tonnes) and the cost of a summer only delivery ($50/tonne x 80,000 tonnes).

10.4 Conclusions

The cost of shipping supplies to the drill site during winter freeze-up is summarized as:

LTA 20-1 - Low	$245/tonne
LTA 20-1 - High	$491/tonne
Air Cushion Vehicle	$396/tonne
Icebreaker Supply	$ 90/tonne

The LTA 20-1 is competitive with the air cushion vehicle but not the icebreaker. The main advantage of the LTA 20-1 over an icebreaker supply vessel is that it is only one quarter of the initial cost and is more flexible to be used for other purposes once the year long supply mission is complete.

11.0 REPORT CONCLUSIONS

11.1 Market Applications

There are two main markets for the LTA 20-1:

(a) in missions where existing transportation alternatives impose economic penalties due to time delays, vehicle dimensions, payload, right of way, seasonal restrictions or lack of existing infrastructure and

(b) in missions where transport alternatives do not exist at any cost.

The first market is the one most immediately available to the LTA 20-1 since it provides immediate economic benefits to the user. The second market is long range since this demand will not develop until the capability to supply it is first well established.

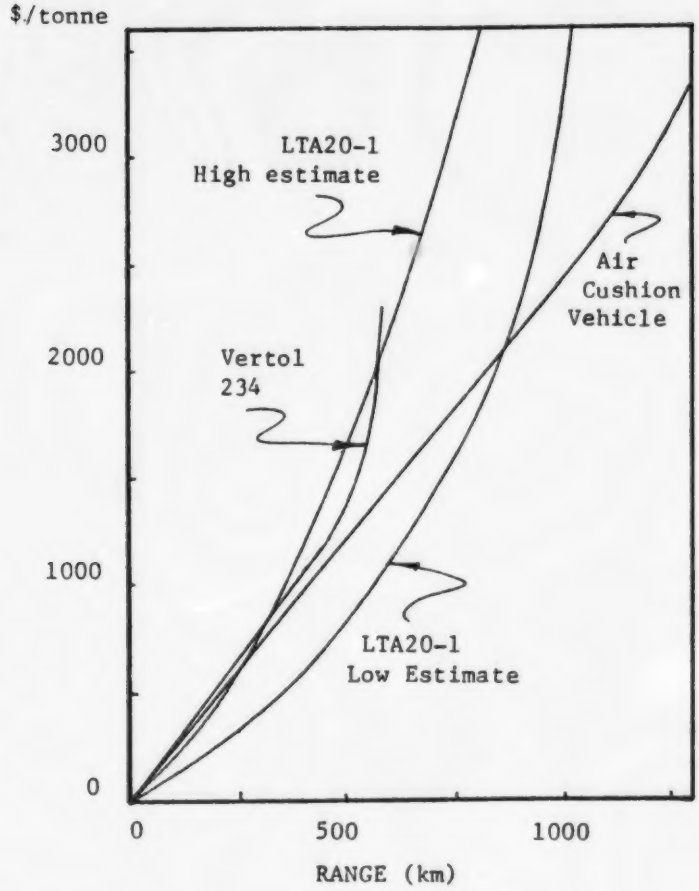
Some specific recommendations can also be made about the most suitable missions for the LTA 20-1.

1. In the case studies examined here the market is for the larger 30 and 55 tonne vehicles. While a smaller vehicle such as the 14-tonne version would be valuable as a demonstrator, its commercial applications would be limited to an aerial crane role. The 14 tonne LTA 20-1 is more efficient in the aerial crane role but the higher speed of a helicopter makes it more cost effective if it has to travel any distance.

2. Figure 11.1 shows the variation in cost per tonne versus range for the 55 tonne payload LTA 20-1, the Boeing Vertol 234 helicopter (12.7 tonne payload) and typical air cushion vehicle costs. The practical range limit for the LTA 20-1 is about 800 km. Beyond this distance the cost per tonne increases rapidly unless the vehicle can be refuelled. Below this range the LTA 20-1 is competitive with both helicopter and air cushion vehicles at the lower cost estimate.

Figure 11.1

COST/TONNE VS RANGE



11.2 Future Work

The market for the LTA 20-1 vehicle in the short term will be for those missions where it produces immediate cost savings compared to alternative methods of transport. For the range of operating costs used these savings are realized in the short range missions.

The feasibility of using the vehicle in these missions will ultimately depend on a well defined operating cost and at present only a high and low cost estimate are available. Before these applications can be examined in any more depth the vehicle operating costs will have to be defined more closely. This in turn cannot be done until the vehicle itself is defined in detail and accordingly further analysis of these case studies should not be carried out until the vehicle definition is completed.

11.3 Recommendations Regarding Phase Ii

This report presents Phase I results of a two phased study. Phase I of the study identifies, candidate missions worthy of further, detailed analysis and evaluation. This further analysis and evaluation represents Phase II of the study.

As several of the missions examined indicated that the LTA 20-1 could reduce transport costs compared to conventional means of transport. it is recommended that Phase II proceed, but only after the LTA 20-1 operating costs have been defined more closely as noted by Section 11.2 above.

BIBLIOGRAPHY

1. Lyall, P.D., Unpublished Vehicle Performance Model, ADI Limited, December, 1985.

2. McKinney, W.D., Test No. T123S, unpublished report prepared for Magnus Aerospace, University of Toronto Institute for Aerospace Studies, January, 1984.

3. "Typical Current Charges for Helicopter Offshore Oil Service in U.K. Sector of North Sea", United Technologies, Sikorsky Aircraft, 1983.

4. Stephen, T., "Lighter-than-Air Transport", Master's Thesis, York University, Toronto, 1985.

5. Personal Conversation between T. Stephen and representatives from Lavilin Construction, October 1984.

6. Personal Conversation, Bob Elliot, Aviation and Fire Management Center, Ministry of Natural Resources, Sault Ste. Marie, Ontario. Nov. 1985.

7. Personal Conversation, Ernie Carlson, Engineering and Architecture Branch, Ontario Regional Office, Indian and Northern Affairs, Thunder Bay, Ontario, Oct. 1985.

8. Personal Conversation with Fred Welling, Engineering and Architecture Branch. Indian and Northern Affairs. Headquarters. Hull, Quebec. Oct. 1985.

9. "Truck Operating Costs in Canada," Trimac Transportation, Calgary, Alta., 1985.

10. "Western Arctic Transportation Study", prepared for Department of Indian and Northern Affairs, by Prolog Planning Inc., Calgary, Alta., June 1985.

11. Personal Conversation, Gulf Canada Resource, Logistics Dept., Calgary, Alta., Nov. 1985.

APPENDIX A

OPERATING COSTS

HIGH AND LOW ESTIMATES

LTA 20-1

OPERATING COST - WORK SHEET

14 TONNE - LOW ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $.50 per litre, 759 l. per hour	397	
- Lubricants @ 1% Fuel Costs	4	
Total Fuel and Lubricants		401
Direct Maintenance and Spares		
- Maintenance @ $30 per Man-hour and 2.0 Man-hour per flight hour	90	
- Reserve for Dynamic Components	350	
- Reserve for Engine Overhaul and Repair	333	
- Reserve for Airframe	275	
- Reserve for Main Envelope	175	
Total Direct Maintenance And Spares		1,223
TOTAL ESTIMATED DIRECT OPERATING COSTS		1,624

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,330
Insurance		
*- Hull Coverage @ 4% Insured Value	160,000	
- Liability, etc. @ 0% Insured Value	0	
Total Insurance Costs		160,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $8 million initial cost		480.000
Operator Determined Costs		
- Overhead		500.000
TOTAL FIXED ANNUAL OPERATING COSTS		$1.351,330

TOTAL HOURLY OPERATING COST

Utilization	hrs.	1,500	2,000	2,500
Fixed Costs	$	901	676	540
Direct Costs	$	1,624	1,624	1,624
TOTAL OPERATING COST ESTIMATE PER HOUR		$ 2,525	$ 2,300	$ 2,164

*Based on $4 million average depreciated value

OPERATING COSTS

While direct operating costs cannot be determined with certainty at this stage, some estimate is required to assess the market potential of the craft in a given role. A high and low operating cost has been estimated for each vehicle to reflect the range of operating costs. These are summarized here as total cost/hr or cost/hr plus fuel based on 1,500 hrs per year.

TABLE
DIRECT OPERATING COSTS
($/HR)

	Low	High
14 tonne	$2,525/hr (2,128 + 795 l./hr)	$4,103/hr ($2,513/hr. + 1,060 l./hr)
30 tonne	$3,844/hr (2,952 + 892 l./hr)	$7,102/hr ($3,534 + 2,379 l./hr)
55 tonne	$5,737/hr ($4,237 + 3,000 l./hr)	$11,501/hr ($5,493 + 4,005 l./hr)

The main difference between the low and high costs is due to the price of fuel assumed ($.50/l and $1.50/l. respectively). The basis for the operating costs is presented in the tables which follow.

LTA 20-1

OPERATING COST - WORK SHEET

14 TONNE - LOW ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $.50 per litre, 759 l. per hour	397	
- Lubricants @ 1% Fuel Costs	4	
Total Fuel and Lubricants		401
Direct Maintenance and Spares		
- Maintenance @ $30 per Man-hour and 2.0 Man-hour per flight hour	90	
- Reserve for Dynamic Components	350	
- Reserve for Engine Overhaul and Repair	333	
- Reserve for Airframe	275	
- Reserve for Main Envelope	175	
Total Direct Maintenance And Spares		1,223
TOTAL ESTIMATED DIRECT OPERATING COSTS		1,624

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,330
Insurance		
*- Hull Coverage @ 4% Insured Value	160,000	
- Liability, etc. @ 0% Insured Value	0	
Total Insurance Costs		160,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $8 million initial cost		480,000
Operator Determined Costs		
- Overhead		500,000
TOTAL FIXED ANNUAL OPERATING COSTS		$1,351.330

TOTAL HOURLY OPERATING COST

Utilization	hrs.	1,500	2,000	2,500
Fixed Costs	$	901	676	540
Direct Costs		1,624	1,624	1,624
TOTAL OPERATING COST ESTIMATE PER HOUR		$ 2,525	$ 2,300	$ 2,164

*Based on $4 million average depreciated value

LTA 20-1

OPERATING COST - WORK SHEET

14 TONNE - HIGH ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $1.50 per litre, 1,060 l. per hour	1,590	
- Lubricants @ 1% Fuel Costs	16	
Total Fuel and Lubricants		1,606
Direct Maintenance and Spares		
- Maintenance @ $30 per Man-hour and 3.0 Man-hour per flight hour	90	
- Reserve for Dynamic Components	350	
- Reserve for Engine Overhaul and Repair	333	
- Reserve for Airframe	275	
- Reserve for Main Envelope	175	
Total Direct Maintenance And Spares		1,223
TOTAL ESTIMATED DIRECT OPERATING COSTS		2,829

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,330
Insurance		
*- Hull Coverage @ 8% Insured Value	400,000	
- Liability, etc. @ 4% Insured Value	200,000	
Total Insurance Costs		600,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $10 million initial cost		600,000
Operator Determined Costs		
- Overhead		500,000
TOTAL FIXED ANNUAL OPERATING COSTS		$1,911,330

TOTAL HOURLY OPERATING COST

Utilization	hrs.	1,500	2,000	2,500
Fixed Costs	$	1,274	956	764
Direct Costs	$	2,829	2,829	2,829
TOTAL OPERATING COST ESTIMATE PER HOUR		$ 4,103	$ 3,785	$ 3,593

*Based on $5 million average depreciated value

LTA 20-1

OPERATING COST - WORK SHEET

30 TONNE - LOW ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $0.50 per litre, 1,060 l. per hour	892	
- Lubricants @ 1% Fuel Costs	9	
Total Fuel and Lubricants		901
Direct Maintenance and Spares		
- Maintenance @ $30 per Man-hour and 3.5 Man-hour per flight hour	105	
- Reserve for Dynamic Components	442	
- Reserve for Engine Overhaul and Repair	640	
- Reserve for Airframe	200	
- Reserve for Main Envelope	190	
Total Direct Maintenance And Spares		1,577
TOTAL ESTIMATED DIRECT OPERATING COSTS		2,478

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,445
*- Hull Coverage @ 4% Insured Value	320,000	
- Liability, etc. @ 0% Insured Value	0	
Total Insurance Costs		320,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $12.8 million initial cost		768,000
Operator Determined Costs		
- Overhead		750,000
TOTAL FIXED ANNUAL OPERATING COSTS		$2,049,445

TOTAL HOURLY OPERATING COST

Utilization	hrs.	1,500	2,000	2,500
Fixed Costs	$	1,366	1,025	819
Direct Costs	$	2,478	2,478	2,478
TOTAL OPERATING COST ESTIMATE PER HOUR		$ 3,844	$ 3,502	$ 3,298

*Based on $8 million average depreciated value

LTA 20-1

OPERATING COST - WORK SHEET

30 TONNE - HIGH ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $1.50 per litre, 2,379 l. per hour	3,568	
- Lubricants @ 1% Fuel Costs	36	
Total Fuel and Lubricants		3,604
Direct Maintenance and Spares		
- Maintenance @ $30 per Man-hour and 3.5 Man-hour per flight hour	105	
- Reserve for Dynamic Components	442	
- Reserve for Engine Overhaul and Repair	640	
- Reserve for Airframe	200	
- Reserve for Main Envelope	190	
Total Direct Maintenance And Spares		1,577
TOTAL ESTIMATED DIRECT OPERATING COSTS		5,181

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,445
Insurance		
*- Hull Coverage @ 8% Insured Value	640,000	
- Liability, etc. @ 4% Insured Value	320,000	
Total Insurance Costs		960,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $16 million initial cost		960,000
Operator Determined Costs		
- Overhead		750,000
TOTAL FIXED ANNUAL OPERATING COSTS		$2,881.445

TOTAL HOURLY OPERATING COST

Utilization	hrs	1,500	2,000	2,500
Fixed Costs	$	1,921	1,441	1,152
Direct Costs	$	5,181	5,181	5,181
TOTAL OPERATING COST ESTIMATE PER HOUR		$ 7,102	$ 6,622	$ 6,333

*Based on $8 million average depreciated value

LTA 20-1

OPERATING COST - WORK SHEET

55 TONNE - LOW ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $0.50 per litre, 3,000 l. per hour	1,500	
- Lubricants @ 1% Fuel Costs	15	
Total Fuel and Lubricants		1,515
Direct Maintenance and Reserves		
- Maintenance @ $30 per Man-hour and 4 Man-hour per flight hour	120	
- Dynamic Components Overhaul and Repair	441	
- Reserve for Engine Overhaul and Repair	960	
- Reserve for Airframe	250	
- Reserve for Main Envelope	255	
Total Direct Maintenance And Spares		2,026
TOTAL ESTIMATED DIRECT OPERATING COSTS		$ 3,541

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,760
*- Hull Coverage @ 5% Insured Value	750,000	
- Liability, etc. @ 0% Insured Value	0	
Total Insurance Costs		750,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $20 million initial cost		1,333,333
Operator Determined Costs		
- Overhead		1,000,000
TOTAL FIXED ANNUAL OPERATING COSTS		$3,295,093

TOTAL HOURLY OPERATING COST

Utilization	hrs	1,500	2,000	2,500
Fixed Costs	$	2,196	1,647	1,318
Direct Costs	$	3,541	3,541	3,541
TOTAL OPERATING COST ESTIMATE PER HOUR		$ 5,737	$ 5,188	$ 4,829

*Based on $8 million average depreciated value

LTA 20-1

OPERATING COST - WORK SHEET

55 TONNE - HIGH ESTIMATE

DIRECT OPERATING COSTS PER HOUR

Fuel and Lubricants		
- Fuel @ $1.50 per litre, 4,005 l. per hour	6,008	
- Lubricants @ 1% Fuel Costs	60	
Total Fuel and Lubricants		6,068
Direct Maintenance and Reserves		
- Maintenance @ $30 per Man-hour and 4 Man-hour per flight hour	120	
- Dynamic Components Overhaul and Repair	441	
- Reserve for Engine Overhaul and Repair	960	
- Reserve for Airframe	250	
- Reserve for Main Envelope	255	
Total Direct Maintenance And Spares		2,026
TOTAL ESTIMATED DIRECT OPERATING COSTS		8,094

FIXED ANNUAL OPERATING COSTS

Crew Costs (6 x 35,000)		210,000
Helium		1,760
Insurance		
*- Hull Coverage @ 8% Insured Value	1.600,000	
- Liability, etc. @ 4% Insured Value	800,000	
Total Insurance Costs		2,400,000
Annual Depreciation - Calculated using 15 year depreciable life, 10% residual and 0% interest $25 million initial cost		1.500,000
Operator Determined Costs		
- Overhead		1,000,000
TOTAL FIXED ANNUAL OPERATING COSTS		$5,111,760

TOTAL HOURLY OPERATING COST

Utilization	hrs	1,500	2,000	2,500
Fixed Costs	$	3,407	2,555	2,044
Direct Costs	$	8,094	8,094	8,094
TOTAL OPERATING COST ESTIMATE PER HOUR		$11.501	$10,649	$10,138

*Based on $15 million average depreciated value

APPENDIX B

SUMMARY OF HLA LITERATURE

ALBERTA MODERN AIRSHIP STUDY

FINAL REPORT

JUNE 1978

PREPARED FOR THE ALBERTA MINISTRY OF TRANSPORTATION

BY

GOODYEAR AEROSPACE CORPORATION Akron, Ohio

in hover and low speed flight, (2) improved structural efficiencies while also resulting in greater structural integrity, (3) enormous improvements in propulsion systems, (4) improved avionics, and (5) an improved ability to forecast and communicate weather information.

Development requirements are presented for the modern airships considered. The development of the airships considered can proceed immediately with high technical confidence. Airships can be introduced in the study area in the near term given sufficient development priority. As in the introduction of any new product, successful demonstration is a prerequisite to acceptance. User confidence as well as regulatory agency acceptance are essential elements in the plan to introduce an airship transport service. It is reasonably clear that the private sector will not substantially underwrite the demonstration of a modern airship transportation system. Governmental support appears essential in this area.

Applications for the modern airships considered herein are not unique to the study area. Worldwide there appears to be a demand for significantly greater numbers of vehicles than in the study area. The expanded market possibilities attendant with this factor accentuates the already strong entrepreneurial interests found in the private sector within Alberta in terms of operating an airship transport service.

1.0 SUMMARY

The application of modern airships in meeting current and projected industrial transportation needs of Alberta and Alberta-based industries has been investigated. Based upon the study results presented herein, it is concluded that modern airships offer significant economic advantage as an adjunct to the developing transportation system within the study area. The study results also indicate that the establishment of an airship operating company (rental service) is both essential to the introduction of airships in the study area and is a viable business opportunity for the private sector.

Heavy Lift Airships (HLA's) which combine proven airship and helicopter components and technology, and modern conventional airships (both rigid and non-rigid) have been considered during the study. A range of HLA's, varying in useful load capability from 45,372 to 142,468 kg (50 to 157 tons*) and modern conventional non-rigid airships varying in useful load capability from 7,260 to 22,686 kg (8 to 25 tons), have been investigated. A large modern conventional rigid airship with a useful load of 151,543 kg (167 tons) has also been evaluated.

HLA's considered during the study are shown to be economically viable in a wide variety of construction industry applications. These applications involve both the movement of construction equipment and project operating equipment. Other economically viable HLA applications reported herein include the transport of

*Refer to Page x for conversion to English units for Figures and Tables

REF: 151/EOI 380

prefabricated structures, transport of oil and gas drilling equipment, and uses within the forestry industry (both fire fighting and logging).

Modern conventional non-rigid airships are shown to have economically viable applications in the transport of both cargo and personnel. Although supporting data has not been developed at this point, personnel within the surveying industry in Canada suggest that a small modern conventional non-rigid airship (useful load of 7,260 kg or eight tons) is economically attractive in a multi-purpose survey related capacity. There also appears to be coastal patrol applications for the small non-rigid airship in Canada.

Large non-rigid airships, 22,686 kg (25 tons), have economically viable applications in moving prefabricated structures, goods and equipment in priority situations as well as considerable application in the transport of personnel.

Large rigid airships have economically viable applications in moving prefabricated structures, goods and equipment to remote areas. The large rigid appears economically preferable to trucks and other special purpose aircraft (e.g. helicopters, Hercules).

Airships are operationally compatible with the Canadian environment and can be effectively operated in the many remote regions of the country. In comparison with previous airship configurations and operations, modern technology significantly enhances the application of airships in the study area due to: (1) improved controllability

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DEC/78

Aviation Planning Services

APS

THE CANADIAN MARKET
FOR HEAVY-LIFT
AERIAL VEHICLES

12. SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

From the thirty-four sets of different, potential HLA vehicle applications, the Consultants selected the six most promising applications for detailed marketability studies. The six most promising applications are given below:

A Series HLA Vehicle Applications
Logging (yarding)
Ship Lightering
Precision Emplacement

B Series HLA Vehicle Applications
Offshore/Remote Area Patrol
Regular Air Freight
Arctic Resupply/Distribution

Based on the field interviews, data analysis and review, the Consultants conclude that only the logging (yarding) application shows any promise as a potential HLA vehicle application. It must be stressed however that the entire analysis is contingent upon the HLA vehicles having the specifications given in Table 12.1. If these specifications are changed significantly, this study's conclusions may have to be altered.

12.1 Logging (Yarding)

Based on the hypothetical logging of the study area on the west coast of Vancouver Island, it was found that the A20 HLA vehicle offered significant savings compared to helicopter logging and effectively competed with the other long

TABLE 12.1

SPECIFICATIONS FOR THE A AND B SERIES HLA VEHICLES

VARIABLES	MEASUREMENT UNITS USED	A Series		B Series	
		A20	A75	B20	B75
		AVERAGE	AVERAGE	AVERAGE	AVERAGE
Overall Length	feet	290	400	150	200
Overall Width	feet	290	400	210	300
Maximum Payload	tons	20	75	20	75
Best Cruise Speed	miles/hour (kilometres/hour) (knots)	35 (55) (30)	50 (85) (45)	70 (110) (60)	105 (195) (90)
Annual Utilization Level	hours/year	1,500	1,500	4,500	4,500
Unit Price(1)	1979 $ (millions)	$3.3	$11.8	$7.4	$26.4
Hourly Direct Operating Cost	$/hour	$520	$2,560	$870	$4,910
Direct Operating Costs Related to Stage Length:					
1 Stature Mile	¢/available ton-mile	180	200	-	-
10 Stature Miles		95	80	-	-
100 Stature Miles		110	80	90	90
500 Statute Miles		120	90	100	90
1000 Statute Miles		-	-	75	75

(1) Production run of 50 vehicles.

SOURCE: Canadair Ltd.

reach logging (yarding) techniques. The average total costs for the six logging systems studied are given below in ascending order of cost per cunit.

	$/Cunit
Running skyline with yarding crane	30.94
Running skyline with fixed spar	34.00
HLA vehicle logging with the A20 vehicle	34.42
Highlead logging	35.52
Balloon logging	39.42
Helicopter logging with the Sikorsky S-64 Skycrane	69.33

The above figures include the costs of road access, falling, yarding, loading and hauling.

The demand for HLA vehicles will be assured as the logging industry is faced with the necessity of harvesting logs in less desirable, and more costly, isolated stands, over-matures stands and young second growth. The supply of readily accessible first growth, high value, mature timber is rapidly dwindling. Thus an efficient, low cost HLA system will make it possible to harvest the mature and valuable timber found in isolated, inaccessible areas and on steep slopes.

By 1990 the long reach yarding techniques could account for as much as 8.4 million cunits of harvested timber on the west coast of British Columbia. The A20 HLA vehicle has the potential to ultimately capture 80 per cent of more of the mature timber market which is accessible only to free flying machines. It will penetrate the ground

based long reach market share to varying degrees depending on its economics relative to the alternative methods. Its share is expected to range from 40 per cent to 80 per cent of the total long reach market by 1990.

This will create a domestic market for about 64 A20 HLA vehicles by the year 1990. The international or export market could demand another 50 to 80 A20 vehicles. Most of these would be used in the United States particularly in Alaska, Washington, Oregon, and northern California. This gives a total world demand in the order of 114 to 144 A20 HLA vehicles by 1990.

The Consultants believed that the A20 is a marketable logging (yarding) vehicle, assuming the Canadair study confirms it is technically capable of performing the logging mission. The Consultants further recommended that a development plan, be prepared, and that a demonstration program be initiated to introduce HLA vehicles to Canada's west coast logging industry.

An effective market demonstration and marketing program will be required in order to sell something which is often perceived as an aviation dinosaur rather than an innovative, new technology. The demonstration must not only prove that a HLA vehicle can physically do the job even in an adverse operating environment, but verify its productivity, operating costs and safety. It has to be viewed as a viable, economical alternative to conventional long reach methods and especially the helicopter.

The primary market impediments the A20 HLA vehicle will have in the logging (yarding) role are the following:

1) The generic relationship and popular association with airships of the Hindenburg era.

2) Helicopter operators, who have built up a fleet of rotary-wing aircraft, have a vested interest in maximizing utilization on their present equipment rather than acquiring a fleet of HLA vehicles.

3) Modern HLA technology is unproved compared to helicopter and more conventional techniques.

4) The physical dimensions of HLA vehicles are a negative attribute for logging (yarding).

The following concept enhancements were raised during the course of the interviews and the Consultants concept review. Each suggestion should improve the marketability of HLA vehicles.

1) Increase the forward airspeed and acceleration of the HLA vehicle. This would reduce ferry times, increase the economical yarding range, and give the HLA vehicle better control performance in mountain turbulence and air currents.

2) Improve the climb/descent performance to exceed 4,000 feet per minute (the Sikorsky S-64 Skycrane climb rate) in order to reduce turn times and increase productivity.

3) Reduce the physical dimensions of the HLA vehicle to simplify handling, mooring and hangarage.

4) Ultimately introduce a fly-by-wire or remotely piloted vehicle control system to the HLA vehicle. This should reduce flight crew costs, improve flight crew and ground crew safety, and perhaps even improve productivity.

12.2 Ship Lightering

Ship lightering is not a promising Canadian, civil HLA vehicle application for the following reasons:

1) The domestic market is too small.

2) The cargo volumes lightered at each point are too small.

3) A HLA vehicle would not get enough utilization.

4) There is insufficient deck space to carry an HLA vehicle.

12.3 Precision Emplacement

The Consultants believe that precision emplacement is not a promising Canadian, civil HLA vehicle application for the following reasons:

1) The 20 and 75 ton payload capability is unnecessary.

2) The domestic market is too small.

3) HLA vehicles are not cost-effective in most cases.

4) Their low forward speed and ceiling makes long distance ferrying impractical.

12.4 Offshore/Remote Area Patrol

This is a B series HLA vehicle application which is a composite of the following similar applications:

1) Remote sensing vehicle.

2) Aerial sesimic survey vehicle.

3) Ice and fisheries surveillance.

4) Pipeline and transmission line patrol.

It was concluded that remote sensing and seismic survey work are not promising Canadian, civil applications for HLA vehicles for the following reasons:

1) The HLA vehicles' payload capability is excessive and unnecessary.

2) Their long airborne endurance attribute is unnecessary.

3) Their low forward speed and ceiling makes long distance ferrying prohibitive.

4) They would not get enough annual utilization.

5) HLA vehicles are not economically competitive.

6) Both the domestic and international markets are too small.

7) The platform stability of the HLA vehicle for tropical work is unknown.

The ice and fisheries surveillance mission is not a promising Canadian, civil application for HLA vehicles for the following reasons:

1) The domestic market is too small.

2) The HLA vehicles' payload is excessive.

3) The long endurance capabity is not useful or necessary.

4) The low forward speed is a handicap.

Finally, the pipeline and transmission line patrol application was dismissed out-of-hand because there is no "heavy-lift" requirement.

12.5 Regular Air Freight

The movement of regular air freight is not a promising Canadian, civil application for HLA vehicles for the following reasons:

1) HLA vehicles are too slow.

2) HLA vehicles are not economically competitive.

3) Their service ceiling is too low.

12.6 Arctic Resupply/Distribution

It was concluded that northern resupply and distribution are not promising applications for HLA vehicles for the following reasons:

1) They are not economically competitive.

2) The cargo volumes to be moved are too small.

3) HLA vehicles are too slow.

4) The market size is too small.

5) HLA vehicles cannot get enough utilization.

6) The acquisition price is too high.

NASA CR-152202

STUDY OF CIVIL MARKETS FOR HEAVY—LIFT AIRSHIPS

DECEMBER 1978

PREPARED UNDER CONTRACT NO. NAS2-9826

BY

BOOZ•ALLEN APPLIED RESEARCH
BETHESDA, MARYLAND

FOR

AMES RESEARCH CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Distribution of this report is provided in the interest of information exchange. Responsibility for the contents resides with the author or organization that prepared it.

1. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1.1 Summary

A study of the civil markets for Heavy-Lift Airships (HLA) has been conducted, in which HLA are defined as combining buoyant and powered lift, and are designed to

- Carry oversize and overweight payloads (compared to conventional transport modes) from 25 to 500 tons (or more as required by the application)
- Travel over relatively short distances, up to about 200 miles (or more as required by the application)
- Hover with precision for significant periods.

Domestic and worldwide heavy lift market areas have been assessed for HLA applicability and the more promising areas have been identified. Studies of HLA operations were conducted to define the operational factors on which HLA design and costs depend. Detailed cost studies of specific heavy lift activities (case studies) have been performed in each of the promising areas to establish the costs of performing heavy lift services using current methods and to establish the methods by which the HLA could be used competitively. From these, an HLA "threshold cost" was determined (defined as the HLA job cost that makes performing the services with an HLA equal in cost to the conventional approach.) The extent of market penetration in each market area was assessed as a function of the extent by which the HLA threshold cost exceeded the HLA job cost estimate.

HLA job cost estimates used in these market penetration analyses were made by averaging the job cost estimate for two different HLA concepts, the Goodyear Quadrotor and the Canadair Aerocrane. The estimates for each individual concept were not used, since these were based on proprietary data from Goodyear and Canadair.

The number and size of HLAs required in each application were determined from the market assessment, the market penetration analyses, and the estimates of HLA costs. The study concluded with an assessment of the operational requirements of each application and other features that significantly influence HLA success.

Specific guidelines for the study encompassed the following:

- A broad analysis was needed, not encumbered by regulations or other institutional factors. Safety, environmental, regulatory, and insurance implications should be noted but not limiting
- Vehicle parametric analysis or design definition work was to be obtained from previous studies of the Goodyear Quadrotor HLA concept
- Consider vehicle operations in the 1980-1990 time frame
- Consider payloads from 25 tons to 500 tons, with particular emphasis on the 50-100 ton payload range
- Consider adverse weather impacts on the effectiveness of HLAs in each application
- Consider HLA operation in rough terrain and/or remote areas
- HLAs with 75 to 100 tons payload must meet the Navy's short haul, heavy lift air system requirements whenever feasible
- The study was to be as concept-independent as possible
- Foreign markets were also to be considered
- A maximum range of 200 miles was to be considered
- Assume that base operations provide only open mooring
- Consider both Government and private financing alternatives.

Study results show a strong case for HLAs around the 75 tons payload range, with major applications in logging, and other opportunities in unloading containers, placing electric power transmission towers, support of remote drill rig construction, and high rise construction.

In addition, cases have been made for larger sizes (150 to 800 tons) in support of power generating plant construction, offshore oil drill rig construction, general transportation and rigging, and strip mining. These results are summarized in Tables 1-1 and 1-2. The numbers of HLA presented are, in general, conservative since they assume no ferry requirements, and a full 2000 hours per year utilization. Accounting for possible annual ferry requirements introduces wide variations in these numbers; these variations

TABLE 1-1 HLA Development Summary

HLA DEVELOPMENT MARKETS	PAYLOAD (TONS)	HEAVY LIFT MARKETS	APPROXIMATE TOTAL POTENTIAL HLAs** 25 MPH	or 80 MPH	REQUIRED VEHICLE CHARACTERISTICS
1	25	Logging, Unloading ships, Tower erection, High rise construction, Remote drilling support.	170*	1120 (If no "75 ton" HLA)	These two market areas are sufficiently large to allow several vehicles to eventually be developed, each one with a set of characteristics suited to a market segment. Generally the required characteristics would be as follows: Cost: As low as possible, relatively unaffected by operating conditions. Altitude: Up to 6-7000, occasionally to 12,000 Temperature: Below freezing to +120°F Elevation Change per cycle: 500 feet to 3-4000 feet Wind: Horizontal and vertical gusts to 30 mph., occasional horizontal gusts and winds to 70-100 mph Precision: Horizontal 1 to 5 feet, Vertical 1 to 5 feet, Descent rate 5 feet per second. Ground riggers to control lateral movement of load. Logistics: Prompt attention to schedule. Load: Aggregate as much as possible (creates high drag) Environment: Improve on helicopter and surface transport capability with respect to – bad weather, bad visibility, day or night, – icing, rain, snow, – rough water and rough terrain. Safety: Static charges, load gyrations, multiple engines, load release, cable snap back, pilot fatigue, ground crew clearance, rotor clearance; load swinging clearance; rigging crew safety on top of high structures.
2	75	Logging Unloading ships Pipeline construction	550*	820 (If no "75 ton" HLA)	
3	150 to 300	Support of power plant construction, strip mining	12	7	These two markets are small and relatively specialized. Possibly can be satisfied by selecting one size in the range of 150 to 300 tons, used in multiples to satisfy the less frequent, heavier lifts. Generally the required characteristics would be as above, plus greater precision in hover, – horizontal and vertical position, within a few inches. – rate of descent, within a few inches per second.
4	500 to 800	Offshore drill rigs, Power generating plants, General transportation	8	7	

*Smaller numbers at lower speeds reflect the reduction in the HLA logging market against conventional competition at these speeds, which appears any increase in numbers based purely on productivity.

**Assumes 2,000 hours utilization. See Table 1-2

TABLE 1-2. HLA Market Summary

APPLICATION	ANNUAL MARKET		UNITS	MARKET CAPTURE POTENTIAL	BEST VEHICLE PAYLOAD (TONS)	*POTENTIAL NO OF VEHICLES		PARAMETERS CRITICAL TO REACHING STATED MARKET CAPTURE POTENTIAL
	NORTH AMERICA	WORLD TOTAL				25 MPH or	50 MPH	
Transportation and Erection of Refinery and Petrochemical Plant Components	0.8×10^6	2.3×10^6	Barrels per day	0	150 200 500 800	(1) 0 (1, or (2) (1)	(1) 0 (1) (2) (1)	If HLA cost can be reduced to 50% of case study estimate, capture potential becomes 100%, resulting in numbers in parentheses.
Support of Construction of Offshore Permanent Drilling and Production Platforms for Oil and Gas	40 to 80	80 to 160	Platforms constructed per year	≈ 100	500	2	2	Low HLA cost, high conventional barge cost, low offshore distance
Movement of Strip Mining Power Shovels	50	Not Available	Shovels moved per year	≈ 200	200 to 300	1	1	Low HLA cost, low round trip distances
Support of High Voltage Power Transmission Line Construction — 345 KVA	4000	12,000	Miles of line construction per year	≈ 100	75 to 30	12	9	Increase in round trip distance increases number of vehicles
500 KVA	1200	4,000						
765 KVA	200	670						
Electric Power Generating Plant Construction	26200	85000	MW generating capacity added per year	100	150 and 200 to 300 and 800	1 (44)* and 10 (33) and 1 (10)	1 (43)* and 8 (27) and 1 (10)	No critical parameters for two sub-applications * If the HLA costs on the oiled sub-application can be reduced by a little over 50%, the numbers in parentheses result
Support of the Construction of Gas or Oil Pipelines	2400 to 2700	10000 to 12000	Added pipeline mileage per year	≈ 100	75	3	4	No critical parameters
Support of the High Rise Construction Industry — HVAC,	4700 to 5200	Not Available	Number of lifts per year	≈ 100	7 to 15 and 25 to 30	1	1	No critical parameters
Window Wash,	8000 to 8000					2	2	
Crane.	250 to 300							
Support of Remote Drilling Installations and Operations	34	100	Wells drilled per year	100	75 to 30	8	3	Increase in round trip distance increases number of vehicles
Logging	7200*	75 to 80,000	Millions of cubic feet per year	≈ 100	7 to 15 or 25 to 30 or 75	100** or 112 or 530	100** or 1082 or 800	Increase in yarding distance increases number of vehicles. Increase in load/unload time increases number of vehicles
Unloading Cargo on Completed Ports	0	270,000 to 670,000	Number of containers moved per year	≈ 100	25 to 30 or 75	37 or 13	27 or 10	Lower HLA cost, higher cost of competition, all increase number of vehicles. Increased trip distance rapidly decreases 75 ton, 25 mph market; the remainder have sufficient in reserve to be unchanged
Transportation and Rigging of Heavy and Oversized Components	300 to 800	600 to 1600	Number of moves per year	80 to 100 0	800 and 800	8 0	4 0	Reduction of HLA cost of up to 50% would result in 100% market share for both sizes. Number of 500 ton vehicles increases with distance travelled.

* These figures are for an assumed 2,000 hours per year utilization, without ferry. If this utilization is reduced to 1,000 hours, not including ferry, the number of vehicles increases by approximately a factor of 2.

** Low numbers at low payload reflect higher unit costs for HLA and low market share. Lower numbers at lower speed reflect lower market due to higher costs, as opposed to increased numbers due to productivity

depend critically on the specific characteristics of each application. Thus the effect of ferry must be assessed on a case-by-case basis.

Discussion of the study results encompasses operational requirements, features that promote HLA profitability, military compatibility, probable institutional influences on HLA design and development, suggested modification to the current quadrotor point design, and an approach to entry into service.

1.2 Conclusions

The study concludes that several promising civil markets have been identified for heavy-lift airships, notably in logging, relief of port congestion, power transmission line erection, construction of power generating plants, and general transportation. A strong case for military commonality has been identified for a 75-ton payload HLA. The most promising long-term payload size is around 75 tons, for which between 550 and 620 appear to be needed worldwide (10 percent of which occurs on the North American continent) primarily for the logging market, with some additional use in relief of port congestion, and construction of pipelines. The bulk of this market can alternately be served by about 1120 25-ton vehicles, providing they can be operated at relatively high speed (around 60 mph) rather than slow speed (around 25 mph). The 25-ton payload also supports power transmission line construction, high rise construction and remote drilling sites. Larger payload vehicles are required in significant quantities; 6 to 11 200-ton to 300-ton vehicles to support power generating plant construction, and 6 to 7 500-ton vehicles to support offshore oil rig construction, and general transportation. One each of 150-ton and 800-ton can also be used in support of power generating plant construction.

To ensure that the markets identified can be captured, careful and detailed study is required to assess the implications of alternative basing strategies, to more fully define the real life markets, and to optimize vehicle configurations, characteristics and costs. Entry into service may be effected through development of a government-sponsored prototype for military and civil applications, or by purely private development activities. In either event, very close coordination with the potential user community is essential, so as to prepare operational requirements that fully satisfy the potential customer, and to minimize adverse effects that may be introduced by institutional concerns. The earliest entry would appear to be in the logging industry, initially in direct competition with the helicopter, at payloads of about 25 tons. Further definition and refinement of HLA sizes, families and numbers depends on development of a wider technical, marketing, cost and operational data base.